

REMARKS

Claims 1, 4, 12, 20, 22, and 30 have been amended to include the limitations. Claims 3 and 21 have been canceled. New independent claim 33 has been added and no claims have been cancelled. Claims 1-33 are therefore pending and presented for review. Favorable reconsideration and allowance are requested in light of the remarks which follow.

1. Rejections Based on Prior Art

Claims 1-32 stand rejected under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 6,561,157 to Zur Loye et al (the Zur Loye et al patent). This rejection, insofar as it is applied against independent claim 16 and dependent claims 2 and 21, the limitations of which have now been added to claims 1 and 20, respectively, is respectfully traversed.

a. Recapitulation of Invention¹

Briefly described, the invention relates to a multimode engine which seeks a smooth transition phase between operating modes. In general, the multimode engine switches between a default pilot ignited gaseous fuel mode and a diesel mode depending on operating conditions at any given time. Namely, under either (i) very light load under all engine speeds, or (ii) at high load combined with low speed conditions, the engine operates in a diesel mode. In all other circumstances and operating conditions, the engine operates in a pilot ignited gaseous fuel mode.

¹ This Section 1(a) is presented for background purposes so the Examiner may understand the state of the art and, in general terms, the applicant's contribution thereto. It is not intended to constitute a specific traversal of any particular rejection. That task instead is performed in Section 1(b) below.

During the transition phase between the fuel modes, the engine operation is controlled based on factors *other than or in addition to* total fuel energy content to ensure consistent engine torque output. Correspondingly, the engine controls various ones of, e.g., diesel lambda, gaseous fuel lambda, diesel injection timing, pilot diesel injection timing, and ignition timing, based on, for example, limit values for diesel lambda and gaseous fuel lambda. In doing so, the engine transitions between fuel modes without noticeable step changes in performance or torque output, and thus realizes a smooth, non-harsh, transition between the engine fuel modes.

Prior art multimode engines switch between modes either without attempting a smooth transition, or by maintaining a constant total fuel energy content during the transition period. Since diesel fuel and various gaseous fuels have different combustion efficiencies, volumes of different fuels with equivalent energy values, when mixed with equivalent air charges, will output different magnitudes of power within the same engine. Accordingly, despite maintaining constant total fuel energy during the transition, prior art multimode engines can produce non-desired power surges or other engine power output discontinuities, because some fuels combust less efficiently than others. The recited invention provides a multimode engine which transitions between modes by controlling the engine based on factors *other than total fuel energy content*. Specifically, the engine is controlled based on at least one of air/fuel ratio (lambda) and diesel fuel injection timing. Such configurations enable the multimode engine to transition between modes while maintaining a generally constant (or continuously variable) engine power output,

thus providing a smooth transition between modes.

b. Traversal of Rejection

Applicant respectfully traverses the above referenced rejections and asserts that the Examiner misinterpreted and misapplied the cited Zur Loye et al patent. The Zur Loye et al patent does not disclose each and every element of the novel independent claims 1, 16, and 20.

Independent claim 1 recites a method of operating an internal combustion engine which is operable in a diesel mode, a pilot ignited gaseous fuel mode, and transitioning between the two fuel modes during operation. During the transition period, the engine operation is controlled **based on at least one engine operating parameter other than total energy fuel content.** Specifically, the engine is controlled based on at least one of lambda and diesel injection timing. In this configuration, the engine torque is suitably maintained during the transition **to achieve an at least substantially smooth transition between operating modes.**

The Zur Loye et al patent does not and cannot disclose operating a multimode engine by controlling the engine in the transitional period **based on at least one engine operating parameter other than total energy fuel content.**

Before discussing the specific defects in the Examiner's rejection, it should be noted that the devices and methods of the Zur Loye et al patent differ substantially from those of applicant's invention.

To characterize the numerous differences therebetween, attention is first paid to general approach that the Zur Loye et al patent teaches for a transition between fuel modes. The Zur Loye et al patent teaches methods of controlling a homogenous charge multi-fuel engine to switch between fuel modes while attempting to maintain total fuel energy levels constant, while e.g. ignoring lambda and diesel fuel injection timing. Thus, by definition, the Zur Loye et al patent is decisively flawed as an anticipatory reference against applicant's invention.

Turning now to the substance of the rejection of claim 1, applicant disagrees with the Examiner's assertion, on Page 2 of the Office Action, that:

"Zur Loye et al teach a method comprising the steps of operating an internal combustion engine in a first mode comprising one of a diesel mode and a pilot ignited gaseous fuel mode; then operating the internal combustion engine in a second mode comprising the other of said diesel mode and the pilot ignited gaseous fuel mode; and (C) during a transition period between the first and second modes, controlling engine operation based on at least one engine operating parameter other than total energy fuel content to achieve an at least substantially smooth transition between operating modes."

As stated above, the Zur Loye et al patent ONLY maintains constant total fuel energy levels during the transition period, in an attempt to suitably control engine performance while switching between fuel modes. Accordingly, the Zur Loye et al patent requires controlling an engine by means which are in stark contrast to that of applicant's invention.

Referring to the express teaching of the Zur Loye et al patent, it teaches at Column 18,

Lines 47-51 that:

“[b]ecause the manifold pressure doubles with the snap opening of the throttle, the amount of natural gas entering the cylinders doubles. However, elimination of the diesel negates that effect thereby allowing the total fuel energy (power) to remain essentially constant.”

Since the device of the Zur Loye et al patent strives merely to maintain transition period fuel delivery having a constant total fuel energy, it does not controlled the engine based on at least one engine operating parameter (specifically, lambda and/or diesel injection timing) other than total energy fuel content.

Thus, contrary to the Examiner's assertion, the Zur Loye et al patent cannot disclose each and every element of applicant's novel claim 1, whereby claim 1 is therefore believed to patentably define over the cite prior art, and in a condition for allowance.

Nor does the Zur Loye et al patent identically disclose each and every limitation of claims 2 and 4-15, whereby these claims are allowable as depending from allowable claim 1, as well as on their own merits.

For instance, referring to claim 11, the Zur Loye et al patent does not and cannot teach controlling a multimode engine during a transition period by determining the gas lambda-rich

limit based at least in part on at least one of manifold absolute pressure and air charge temperature.

Independent claim 16 recites a method of operating an internal combustion engine which is operable in a diesel mode, a pilot ignited gaseous fuel mode, and transitioning between the two fuel modes during operation. During the transition period, controlling engine operation **based on multiple engine parameters including lambda to achieve an at least substantially smooth transition between operating modes by maintaining total engine torque at least substantially constant.**

The Zur Loye et al patent does not and cannot disclose operating a multimode engine by controlling the engine during the transitional operation **based on multiple engine parameters including lambda.**

The reasons are largely the same as those discussed above. Namely, the device of the Zur Loye et al patent *only* considers total fuel energy and strives to maintain a constant value thereof during the transition period. The Zur Loye et al patent does not discuss, with any specificity, detailed air/fuel ratios and thus fails to disclose any suitably methods of monitoring, determining, and/or making operating decisions based on lambda values in any regard.

Nor does the Zur Loye et al patent identically disclose each and every limitation of claims 17-19, whereby these claims are allowable as depending from allowable claim 16, as well as on their own merits.

For instance, referring to claim 17, the Zur Loye et al patent does not and cannot teach controlling a multimode engine during a transition period by **controlling diesel lambda to be at a relatively high value at the beginning of the transition period and thereafter reducing diesel lambda toward a smoke limit by the end of the transition period.**

Independent claim 20 recites an internal combustion engine with: at least one cylinder; a source of diesel fuel configured to supply a liquid fuel to the cylinder; a source of a gaseous fuel configured to supply a gaseous fuel to the cylinder; and a controller that is coupled to the diesel fuel source and the gaseous fuel source which selectively controls the delivery of the different fuels. The controller operates the engine in one a diesel mode and a pilot ignited gaseous fuel mode, and then the other of the diesel and pilot ignited gaseous fuel modes. During the transition between fuel modes, the engine operating is controlled **based on at least one engine operating parameter (specifically, lambda and/or diesel injection timing) other than total energy fuel content to achieve an at least substantially smooth transition between operating modes.**

Again, the Zur Loye et al patent does not and cannot disclose a multimode engine which is controlled during the transitional period based on at least one engine operating parameter other than total energy fuel content.

Here too, the reasons are largely the same as those discussed above. Devices of the Zur Loye et al patent *only* consider total fuel energy and strive to maintain a constant value thereof during the transition period.

Nor does the Zur Loye et al patent identically disclose each and every limitation of claims 21-32, whereby these claims are allowable as depending from allowable claim 16, as well as on their own merits.

For instance, referring to claim 24, the Zur Loye et al patent does not and cannot teach a multimode engine with a controller, wherein at the beginning of the transition period, the controller is operable to determine the diesel lambda limit by multiplying the determined actual gas lambda by a multiplying factor.

For the reasons stated above, the Zur Loye et al patent do not disclose all elements of the inventions of the pending. The rejections of claims 2, 4-15, and 17-32, each of which depend directly or indirectly on claims 1, 16, or 20, respectively, should therefore be withdrawn.

2. New Claim and Conclusions


New claim 33 is generally commensurate in scope with claims 1, 16, and 20, while reciting with more specificity the non-total energy fuel content factors, and is believed to be in a condition for allowance for at least generally the same reasons discussed above in connection with claims 1, 16, and 20.

It is believed that each of the Examiner's rejections have been addressed by argument, and that each of the now pending claims 1, 2, 4-20, and 22-33 is in condition for allowance. Such action is respectfully requested. The Examiner is strongly urged to contact applicants' attorney by telephone with any remaining questions, if such telephone contact would help expedite allowance of the claims.

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Page 21

Authorization is hereby given to deduct Deposit Account No. 50-1170 in the amount of \$100.00 for a fourth independent claim (i.e. one in excess of three) for a small entity. Should the Examiner consider any other fees to be payable in conjunction with this or any future communication, the Director is authorized to direct payment of such fees, or credit any overpayment to Deposit Account No. 50-1170.

Respectfully submitted,


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